LOCAL STRATEGIC NETWORKS AND POLICIES IN EUROPEAN ICT CLUSTERS

The cases of Amsterdam, Bari, Dublin and Oulu

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Willem van Winden
Paulus Woets

European Institute for Comparative Urban Research
Erasmus University Rotterdam

1. INTRODUCTION

Regional interfirm networks are believed to be a vehicle for innovation and regional economic growth. From this perspective, local and regional governments are increasingly trying to promote these types of networks. This article discusses the relation between strategic networks and local development. It focuses on the role of local institutions that support strategic networking in ICT clusters in a number of European cities. It also discusses and analyses the way local and national governments try to influence local strategic networks in this sector.

Our case studies are Amsterdam, Bari, Dublin, and Oulu[1]. This paper is based on the results of an EU-funded research project entitled MUTEIS (Macro-economic and Urban Trends in Europe's Information Society), that aims to provide deeper insights in the emerging digital economy in urban regions.

This article has a number of aims. First, it wants to illustrate the highly diverse development of ICT clusters in different urban and national contexts during the 1990s. Second, the paper aims to contribute to the ongoing discussion in economic geography and regional/urban economics about the relative importance of local and global linkages in urban innovation systems and clusters. Third, it aims to give insights in the role of local institutions in the functioning of ICT clusters. Among other things, it shows that although the local support mechanisms for ICT clusters are of a recent date, they reflect typical national and local habits and attitudes concerning the roles of the public and the private sector. Fourth, the paper wants to yield some policy lessons as to how local governments may promote local ICT clusters.

This paper is organised as follows. Section 2 contains a literature review on the relationship between networks, clusters and local/regional economic development. On the basis of that, section 3 presents a frame of analysis that helps to organise and structure the case studies. In section 4, four case studies are presented. Section 5 concludes.

2. STRATEGIC NETWORKS, CLUSTERS, AND LOCAL DEVELOPMENT: A LITERATURE OVERVIEW

There is a vast and growing literature about the development of local clusters, strategic networking and regional development. In the brief space available here, we cannot claim to give a complete overview of what has been written in this field. Given the scope of the article,

[1] For the cases of Bari, Dublin and Oulu we are heavily indebted to our colleagues in the MUTEIS consortium. The Bari case study was originally written by A.P. Russo (Erasmus University Rotterdam);

we focus on the spatial dimension of strategic networks, and the role of (local) governments to support or enhance strategic networks to the benefit of regional economic development.

Miles and Snow (1984) consider networks as something that entrepreneurs use purposefully to gain a competitive advantage. Engagement in networks has several well-documented advantages (Jarillo, 1993; Castells, 1996; and many others). It makes for flexibility: to grasp business opportunities, a firm has to be able to react fast, and to engage in partnerships with complementary strengths and capabilities. Networks are particularly important regarding innovation. Strong international competition and rapid technological development urge firms to produce new products, develop new processes and access new markets. Participation in a network enables a firm to concentrate on core capabilities, and provides access to resources (such as specific know-how, technology, financial means, products, assets, markets etc.) in other firms and organisations. This helps them to improve their competitive position. Jarillo (1988, p.32) comes up with the term 'strategic networks' which he defines as *arrangements among distinct but related for-profit organisations that allow those firms in them to gain or sustain competitive advantage vis-à-vis their competitors outside the network*. In this concept Jarillo considers the 'hub firm' as an essential factor: this company sets up the network and takes a pro-active role in making sure that the network functions well. According to Jarillo strategic networks will only prove to be successful if they are more efficient than pure market relationships and companies internalising business activities.

Strategic networks evolve over time and space. Butler and Hansen (1991) present a model of entrepreneurial network evolution, in which a firm goes through three phases. In the first, entrepreneurial (pre start-up) phase a firm is in the process of opportunity identification: here, the social network plays the dominant role. The second phase is the business start-up phase. In this phase, the process of business formation takes place. Links to individuals and organisations that directly serve the more immediate start-up needs (suppliers, customers, capital providers) are prominent; this is called a business-focused network. The third stage is the ongoing business phase: the period where the firm expands its links to other organisations and becomes part of a strategic network. Generally, the geographic scale of network linkages will grow when firms grow (Koschatzky and Zenker, 1999).

Many contributions in territorial studies have explored the relations between local networks and regional development. The main line of argument is that denser local networks lead to more innovation, which results in favourable local development. Some approaches conceptualise the region as a "learning environment" in which interaction between regional

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the Dublin case study by P. Butler and J. Ihle (Nexus Dublin), and the Oulu case study by V. Mustonen

actors brings innovation and growth (Begg, 1999). The clustering of companies and other institutions (such as polytechnics and universities) is often assumed to contribute to a region's capacity for innovation and learning. Some environments are better for innovation then others. Camagni (1991) speaks of an innovative milieu, which is described as *the set, or the complex network of mainly informal social relationships on a limited geographical area, often determining a specific external 'image' and a specific internal 'representation' and sense of belonging, which enhance the local innovative capability through synergetic and collective learning processes.* Cooke and Morgan (1994) have shown that the innovative milieu is an essential factor for the innovation capacity of regions. Also Lawson and Lorenz (1999) bring up evidence that supports the link between strategic networks and innovation: they argue that both explicit and tacit knowledge are important for collective learning processes that enlarge regional innovative capacity. Since tacit knowledge is best communicated through face-to-face contacts, and because such contacts are facilitated by local strategic networks, such networks contribute to the innovative capabilities of a region.

In many recent studies, the heavy focus on local linkages as sources of innovation has given way to approaches in which the interplay of local and non-local linkages is central. A key question in this debate is how important local networks really are for innovation. For the engineering industry, Alderman (1999) finds that local networks are not at all important for technical development; in this field proximity is not important. Regional innovation cannot be explained by local connections. Local and non-local networks perform different functions: the degree of local engagement is dependant on historical antecedents in the firm and its environment, its strategic vision and the impact of external forces on the company. Asheim and Cooke (1999) find that both local and (inter-) national links are important for innovation. The multi-level aspects of knowledge infrastructures and innovation systems play a critical role; systems and structures at both the local and the global level are important. Depending on their size, organisational form and branch, sectors have different requirements with regard to knowledge infrastructures and innovation systems. While large companies and high-tech SMEs may benefit the most from linear (inter-) national innovation systems, locally-managed, traditional SMEs may find most benefits in interactive, regionally embedded innovation systems. Maskell (1999) argues that in countries with high labour costs, valuable competencies have to be created fast. Companies do this by making links at all levels (from local to global), but relations at the local level have an edge because they are often faster, cheaper and better able to transfer tacit knowledge.

(University of Oulu)

What can be the role of local governments in promoting strategic networking? According to OECD (1999), it is the firms that drive innovation, but governments have three core tasks to support the innovation process: invest in basic scientific research, lay the right circumstances for business innovation, and help to improve the innovation system itself. Asheim and Cooke (1999) observe that a key policy challenge is to improve local links between firms and knowledge infrastructures. They argue that this requires the development of coordinated policy regarding service delivery to SMEs. Such an integrated approach will also demand organisation change in the public sector itself. It seems that there's no single model for successful regional innovation systems. Still, they identify some factors that surely contribute to successful stimulation of innovation: high levels of regional economic and policy autonomy, recognition of the multi-level nature of governing innovation, policies that are inclusive and consultative and a culture that recognises the importance of innovation for job growth and economic development. Asheim and Cooke conclude that technological innovation needs to be recognised as a socially interactive process and for optimum innovation levels, the economic externalities from geographical proximity need to be maximised. This implies enabling interaction by creating situations where hard (technological) and soft (human) infrastructures and networks are in place. Van den Berg, Braun and Van Winden (2001) arrive at very similar conclusions. Additionally, they find that for local cluster development, public-private cooperation is a prerequisite to develop effective and efficient cluster policies. "Interactive policymaking" is needed in the marketing of the cluster, in attracting new firms, in helping start-ups and in all other aspects of cluster policies, to make optimum use of the knowledge and resources of the existing actors in the cluster. This also implies that civil officers in cluster policies need to be well educated and have sufficient "feeling" with the cluster.

Alderman (1999) does not expect too much from local government policy. Successful regions are deemed to possess key factors for innovation like venture capital, skilled labour, a certain local business culture and specific networks, but the meticulous mechanisms that incorporate these factors into product development processes are not identified. This implies that government policy to stimulate such innovation developments stays very much hampered, because the target of such policy remains a 'black box'.

3. FRAME OF ANALYSIS

In the following sections, we will apply some of the notions discussed above to analyse the development of ICT (Information & Communication Technology) clusters in a number of European cities. We are primarily interested in the strategic network configurations in this

sector, their geographical morphology, the institutions that support or enhance networks, and the role of local and regional policy.

For our purposes, ICT clusters are interesting for at least three reasons. In the first place, this sector is a knowledge-intensive sector, characterized by high levels of technological progress and market dynamics. It can be safely assumed that knowledge spillovers (localised or not) are important for these types of activities. For this reason strategic networks can play an important role as channels of knowledge interaction. Second, the ICT sector is a relatively young sector and is generally known for its networked character. This makes it interesting to study the local/regional institutions of ICT clusters that have emerged. They are of recent date, and may differ from institutions in older sectors that have a long history. Third, the ICT sector has received a lot of government attention. Many local governments, during the 1990s, have tried to promote the development of local ICT clusters, inspired by the growth and dynamics of Silicon Valley, the world's prime ICT cluster. However, cities throughout Europe have done so in many different ways, reflecting different national and local contexts.

In the next section of this paper, we describe and analyse the cases of Amsterdam (the Netherlands), Bari (a regional capital in southern Italy), Dublin (Ireland), and Oulu (a booming ICT cluster in northern Finland). The cases were selected because they all have considerable ICT business concentrations and/or policy ambitions to acquire many ICT activities. Also, as they are situated in four different countries, the institutional settings in each of the clusters can be expected to be very different, which makes the comparison more interesting.

Each case study starts with a brief overview of the cluster's development in the last decade, put in the context of the development of the urban region as a whole. Next, in our description, we focus on three elements:

1 **Network nodes**: How can the network actors be characterized? Which sub-sectors are dominant (software, hardware, content (publishing, new media), telecommunications). In which parts of the supply chain (R&D, production, sales/marketing) does the urban cluster specialise? What is the size distribution of companies in the cluster?

2 **Network links**: How can the network linkages be characterised: Is there a focus on sales relationships with customers, linkages with suppliers and contractors, cooperation with regard to marketing or co-operation in innovation and R&D?

What is the geographical reach of the network (local, regional, national or international)? To what extend are universities, polytechnics and other research-oriented organisations involved in local strategic networks?

3 **Institutional network setting**: For each case, we will describe and discuss the institutions of the local ICT cluster. We define the *institutional network setting* as the complex of formal organisational entities in the functional urban region that aim to promote strategic network formation within the ICT sector. This can be traditional organisations (chambers of commerce, branch organisations), but also knowledge exchange platforms, business incubators, or project organisations. We will look how the institutions function, who are leading actors in their creation and operation. In particular, we focus on the role of regional and local governments: to what extent do they promote the development of networks through policy?

4. CASE STUDIES

In this section, we will describe and analyse a number of case studies: Amsterdam, Bari, Dublin and Oulu. For each case-city we thoroughly reviewed the available reports and studies on the ICT cluster and collected as many data as possible. On that basis, we were able to identify key actors in the cluster. Subsequently we executed in-depth interviews with key representatives in the cluster. We have held semi-structured interviews with firms (foreign firms, indigenous firms and start-ups), local and regional government representatives, intermediary organisations and knowledge institutes. Admittedly, the number of interviews (12 to 15 in each city) was too low to produce statistically significant outcomes about network configurations and their geographical scope. For this, a survey would have been a better tool. Nevertheless, the interviews yielded a very good picture of the network activities in the cluster, as we interviewed core actors with knowledge about other actors in the cluster as well. The interviews also yielded very interesting information about the cluster's history and the development of its institutions.

4.1 Amsterdam

Amsterdam is the capital of the Netherlands and is part of the polycentric Randstad area. The region counts some 1,500,000 inhabitants. The city's economy has boomed during the 1990s. Its service sector expanded rapidly, the city managed to attract many headquarters from national and international companies. The number of business start-ups has been relatively high. The economic success of Amsterdam can be ascribed to its high quality of life (vibrant

night life, many cultural amenities etc), and its good international connectivity (Schiphol Airport), both location factors that gained weight during the 1990s.

The urban economy is strongly dominated by services (public sector services, banking and business services). In 2000, the ICT sector accounted for 10% of total employment. In the period 1994-2000 ICT employment growth averaged 6.8% per year (substantially higher than the national average growth of 4.1%) and was one of the cities' key growth sectors. The sector's growth can be explained by large local corporate demand (notably by the financial sector). In addition, Amsterdam's image as "creative city" and it high concentration of media and advertising firms boosted the development of new media companies, especially in the late 1990s.

Network nodes

In Amsterdam, the ICT sector is biased towards content, consultancy, telecom and software (see table 1). Content producing firms are the smallest (average of 3 employees per establishment), while telecommunications companies are the biggest (22 employees). The city hosts some ICT headquarters (probably the best known is Cisco's European headquarters). In the cluster we did not identify a "hub firm" that dominates the local industry. The hardware sector and high-tech research and development in ICT are underrepresented in Amsterdam.

The city has two large universities that produce ICT graduates and execute R&D in ICT and adjacent fields. But also, during the 1990s, Amsterdam's expanding economy and its creative image attracted a lot of ICT talent from other Dutch cities and abroad. As a result, the city has a substantial and specialised pool of ICT-skilled staff.

Table 1: Employment and firms in the ICT and New Media cluster in Amsterdam

Employment and firms in ICT and new media (2002)	ICT-content	ICT-hardware	ICT-software	ICT-telecom	ICT-consultancy	Content	ICT & content total	Other sectors	Total
Number of employees	12,029	3,930	8,572	9,131	6,244	7,300	47,206	370,505	417711
Number of firms	3,751	364	1,297	417	1,112	638	7,579	51,611	59190
Average firm size (jobs)	3	11	7	22	6	11	6	7	7

Source: Amsterdam Statistical Department

It is worth noting that much of ICT competence is hidden in firms that are not in the ICT sector, notably in the big banking and insurance companies.

Network links

The linkages within the Amsterdam ICT cluster strongly vary per sub sector. The small new media companies (very typical for the cluster) are very much locally networked; they typically form partnerships to create products for large corporate customers. Partnerships are mostly project-based. The SME firm managers in ICT know each other personally and are aware of each other's competences. The Amsterdam based foreign multinationals, on the contrary, have only few local linkages. They choose Amsterdam for its excellent external accessibility and the international business climate. Their linkages are primarily international, within the parent company and with customers in a large geographical area. The multinational branch offices mostly are active in marketing, sales and distribution activities.

As noted, ICT-related research and development is a much weaker part of Amsterdam's cluster, and networks in this segment are much less pronounced. Strategic links between the ICT sector and the public knowledge infrastructure (universities/polytechnics) are weakly developed. ICT companies regard the polytechnic and the two universities just as suppliers of (ICT) graduates. The knowledge institutes make limited efforts to transfer their findings to the market parties.

Institutional network setting

The city's ICT cluster has several institutions that support the formation and maintenance of networks. In each of them, the city has played an important role in the start-up phase.

The *Amsterdam New Media Association* (ANMA) is an independent and informal networking organisation for the ICT and new media entrepreneurs in the Amsterdam area. The activities of ANMA aim to strengthen the new media and ICT companies in the region creatively, technically, and commercially. ANMA concentrates on all new media professionals: from graphic designers to programmers, from start-ups to established businesses. It organises network meetings, monitors the new media and ICT cluster and initiates projects to support start-ups and stimulate training and education. ANMA was created in 1998, following an initiative of the Amsterdam Economic Department. During the first period, ANMA was supported by individuals, but since 2002 ANMA only has company-supporters. The board of directors consists of managers from participating companies. ANMA is supported by a committee of regional players interested in the new media sector, such as the chamber of commerce, the Knowledge Circle Amsterdam, and the Province of North-Holland. The founders of ANMA took their inspiration from "Silicon Alley" in New York (a creative ICT cluster focussed on new media). In Amsterdam there were many small, emerging ICT and new media companies. They were mainly technology and application driven. There was an apparent lack of business professionalism and networking capabilities. ANMA was a

municipal initiative aimed at dealing with these shortcomings. Although the municipality supports some activities of the ANMA occasionally, it is now self-supporting on the basis of company contributions. About 7,500 companies in the Amsterdam region are part of the New Media and ICT cluster.

The *Kenniskring* (Knowledge Circle) Amsterdam aims at knowledge transfer between research, education and enterprises. Since its establishment in 1994, the Kenniskring has developed into a broad platform of individuals from the sciences, education, trade and industry as well as from local and provincial government. The Kenniskring was started when studies revealed that only a limited part of all the ICT knowledge available in the Amsterdam region finds its way to product and market development. Kenniskring Amsterdam establishes cooperation and promotes effective use of the existing knowledge infrastructure. The Kenniskring operates on the commitment of over 100 local organizations. Depending on their degree of involvement and capacity for support, these organizations make financial contributions. Seventeen organizations comprise the core donors. The Kenniskring's core activities include setting up projects of knowledge transfer: the Kenniskring develops an idea - working with a group of experts - into a draft proposal. If the proposal proves viable, the Kenniskring launches efforts to recruit financers, after which the project is transferred to the implementer.

Another local “network promoting” institution is the Twinning Centre. This initiative aims to promote promising ICT start-ups in several ways. An important part of the initiative is to create links between new companies and established businesses. This should give young companies easier access to knowledge, technology, markets and capital, and thus increase their chance of business success. In the Twinning Centre Building (located on the Amsterdam Science Park), several start-up companies are located. Twinning is a joint initiative of the City of Amsterdam, and the National Ministry for Economic Affairs. The city of Amsterdam had to compete with other Dutch cities to get funding for the centre, and was successful in its bid.

It may be concluded that the Amsterdam ICT cluster is very successful, based on favourable market conditions. Informal networks dominate, and are supported by newly founded institutions in the 1990s that bypassed old ones (like chamber of commerce). These institutes are supported by local government, but in a rather “light” way. As a consequence, the businesses don’t regard the institutions as vehicles for public policy but rather as something of their own.

4.2 Bari

With 312,000 inhabitants, Bari is one of the largest cities in Southern Italy. The population is decreasing and aging. The city has a large inflow of migrants from Albania and former-Yugoslavia. The urban region makes up the largest part of the province, which has some 1,500,000 inhabitants. Bari presents a number of other peculiarities. First, it possesses a first-class knowledge infrastructure, which is uncommon in Southern Italy. Secondly, the city is oriented towards services, which makes it a real economic capital within the Mezzogiorno, a "Southern Milan". Bari is also a historical, monumental city, whose medieval walled centre has been recently regenerated with funds from the URBAN programme of the European Commission. Per capita income in Bari is far below the national average. As far as employment is concerned, Bari (as the rest of the region) reflects the awkward position of Southern regions. Unemployment is 8 points higher here than in Italy as a whole, and more than four times the rate in the North East. The figures are even larger for juvenile unemployment. Only 3.3% of the population has university education.

Bari's economy is quite diverse. Services, 'light' manufacturing (textile, shoes etc), and mechanical industry (automobiles) are present in the region. The ICT sector is underrepresented in the province of Bari compared to the Italian average.

Network nodes

There are three main agglomerations of ICT producers in the urban region of Bari. One is in the city centre of Bari. In this area there are mainly small firms that supply low added-value ICT services to citizens and firms. There are also several content producers, for instance the main publishers. The city centre ICT-cluster includes as a sub-category, the "executive centre" location, a new complex hosting head offices of banks and service firms as well as the main associations of entrepreneurs. The centre is located strategically on one of the main entrance gateways to the city, close to the scientific campus of the University and the Polytechnic campus. Many ICT firms are located in that centre or in its environs. Thirdly, there is a natural cluster of ICT activity within Tecnopolis science park (TNO). They are spin-offs from TNO, but also partners in specific projects or just firms that share facilities and know-how with the TNO organisation. For instance, the teaching and R&D activities carried out at the science park generate a remarkable number of "satellite" businesses.

Finally, other ICT firms are located throughout the territory, in the main urban centres that have "industrial development areas" (e.g. Modugno, Molfetta, Ruvo, Casamassima with its large "Baricentro" business complex) in their whereabouts, along the main road links, and in the proximity of the manufacturing clusters of the region. These firms may be settled here for idiosyncratic reasons (residence of the managers, cheap land available, good links) or because

in these places they may exploit some kind of advantage from proximity with a group of customer firms.

Telecommunications is the best-performing ICT sub-sector: while the number of employees was stagnant in 1991-1996, since then employee and firm numbers rose sharply. The *hardware* sector is also doing well: in the period 1996-2002 the number of firms increased from 2 to 35. In most recent years the number of employees declined as a result of restructuring. The number of *software* firms increased, but the number of employees per firm decreased to just 2. This small company size probably implies that there is little capacity to innovate. While the City of Bari and its province do fairly well in software products and services as far as the number of firms is concerned, employment in software is going downhill in Bari as in the rest of the country, with a contraction of firm size by 66% in the last half decade. An average firm size of 2 instead of 5.5, as it used to be six years ago, means that today fewer firms have in-house resources to innovate and be on the frontier of development, and instead they are likely to be passively working routines for big firms. Moreover, Bari saw its share of national software employees and firms reduced. The *content* industries present a mixed picture, on the whole favourable, but remarkably driven by the huge increase of firms in sectors such as advertising and publishing. Content producers more than doubled both in Bari and in the Province, while employment went down remarkably less than in the rest of the country.

An important local ICT firm is Abaco Software: it employs 220 people and had €12m in sales in 2002. It is located in Molfetta, a town some 40km from Bari. Abaco has a large, delocalised supply chain. A big foreign firm is IBM: through ACG, a joint venture with Fiat, it sells and maintains IBM-based software applications. IBM is present in Bari since 1992, where they maintain two research and development facilities – namely specialised in e-learning and JAVA technologies – and a regional commercial office. The localisation of IBM first, and then ACG, has enjoyed the financial advantages granted by the national industrial policy for Southern Italy (ex-Law 488).

The University of Bari (strong in science; among others ICT studies) and the Politechnic of Bari (ICT engineering etc) have a good reputation. The region suffers from a brain drain to Northern Italy, but this is not a problem in ICT, since the number of ICT graduates is bigger than the local demand for such employees. Finally, several research institutes are present in Bari. One instance is IBM's e-knowledge and e-management facilities for Italy.

Network links

There is evidence that some firms in the ICT cluster co-operate in order to achieve the critical mass to reduce costs, for instance to deal with customers, organise joint marketing and training initiatives, and hire human resources. However, strategic inter-firm relations that should lead to innovation are limited by lack of clear technological advantages. In fact, the relatively demand-driven nature of the firms' operations and the fact that the biggest, more innovation-oriented customers are in this area because of financial incentives, and not because they want to enjoy a technological advantage, makes information sharing almost unnecessary. The lack of a real local market pull is hindering the process of knowledge upgrading of the region. Only minor routine operations are out-sourced to the small local ICT firms like software houses and database managers. The main ICT producers of Bari realise 80-90% of their sales on the non-regional market.

ACG (the IBM/Fiat joint-venture) buys components and sells its products in a chain that is "global"; hardware and software are directly supplied by IBM and the local supply is limited to a number of small laboratories and software firms, to which ACG outsources the development of low-added value operations in big development projects where flexibility is a key strategic requirement. There are only 2 or 3 long-lasting relationships with sub-suppliers in Bari. However, ACG has a good relationship with the local higher education institutes; among other things, they carry out joint research projects.

Multiple strategic ties exist between the university, the polytechnic and local ICT firms. The national government has given universities more autonomy in recent years. As a result, academic research has become more market-oriented to increase funding opportunities.
Also, the university has joint research projects with ICT firms in the fields of product development and theoretic research, and it provides specialised education like in-company courses. On a higher level, the universities cooperate with the region and Assindustria (association of entrepreneurs) in planning processes.

Institutional network setting

Two organisations act as network leaders in Bari's ICT sector. The first is Tecnopolis, which was founded as a science park in 1969 by the university and polytechnic. For a long time it was the only science park in southern Italy. Tecnopolis mission was to contribute to the modernisation of the region by diffusing knowledge to the private sector, stimulating innovation, supporting start-ups, carrying out applied research and offering training activities. Since the 1980s Tecnopolis has gone through several stages: First, it was an association of public partners, in which the universities and the region were the main shareholders. This

constellation failed because the activities were too much technology-push driven. Subsequently, Tecnopolis became a real company in 1989 called TNO, in which a private engineering company was a key partner. However, TNO came in a financial crisis. Italian government pushed TNO back into its role as an applied research institute. The institute focussed on making profits, as a technological partner in innovation. Training and education were also transformed into profitable activities. TNO was opened up to private shareholders, and received EU funds. In the late 1990s TNO added 'soft' specialisations to its technological focus. The Bari region gave TNO the task to support local administrations in upgrading their organisational and technological systems, but at the same time TNO kept also working for private parties. Currently, these conflicting roles of regulator and competitor in IT services are still both part of TNO. Therefore, ICT firms and universities don't acknowledge Tecnopolis as network leader. Nevertheless, the science park played an important role in Bari's ICT infrastructure development: Tecnopolis resulted in multiple spin-off companies, attracted several university faculties and firms that share facilities and know-how with Tecnopolis.

Secondly, there is Assindustria (the association of entrepreneurs in the province) that is the spider in the private sector web. This actor is trusted by both SMEs and big companies and has a clear vision and strategy on how to put to value the local assets and skills. Assindustria plays a catalyst role in various innovative projects and facilitates contacts between private firms and the universities. The strategic links maintained by Assindustria are mainly local. Assindustria succeeded in bringing a cooperative attitude into the ICT sector and now is also becoming an important actor in increasing the embeddedness of the ICT sector in the region.

The local government doesn't play a significant role in the ICT cluster development. The national government influenced the ICT sector heavily up to the late 1980s through subsidies and fiscal incentives to help backward Southern Italy. Also, the Italian government had a large influence via the telecom incumbent. Nowadays, the ICT sector is mostly influenced by regional policy and EU funds: the Bari region has been very successful in attracting EU funding. Regional initiatives are aimed at stimulating innovation in firms and upgrading the quality of services towards citizens. Also, the use of ICT by public entities is stimulated. The regional plans fit into the national government initiatives.

In sum, the ICT companies in Bari do not participate much in local/regional strategic networks. The foreign multinationals in the region are there because of low labour costs and their R&D, supplier and customer networks are mostly made up of national and international links.

4.3 Dublin

The metropolitan region of Dublin, the capital of Ireland, comprises 1,120,000 citizens (30% of the Irish population). From the late 1980s onwards, its economy has grown very rapidly, and even outperformed the unprecedented expansion of the Irish economy. In the period 1995-2001, growth in Irish GDP averaged 10%, and by 1999, Irish per capita GDP had exceeded the EU average. Dublin dominates in sectors that expanded rapidly, such as commerce, light manufacturing, financial services and professional services. Several factors played a role in the Irish growth process: the country's infrastructure was much improved, helped by massive EU support; foreign direct investment (especially from the US) soared, attracted by low corporate taxes and wages; the educational level of the population increased and many Irish emigrants returned from the US, bringing in new expertise and entrepreneurial activity.

Network nodes

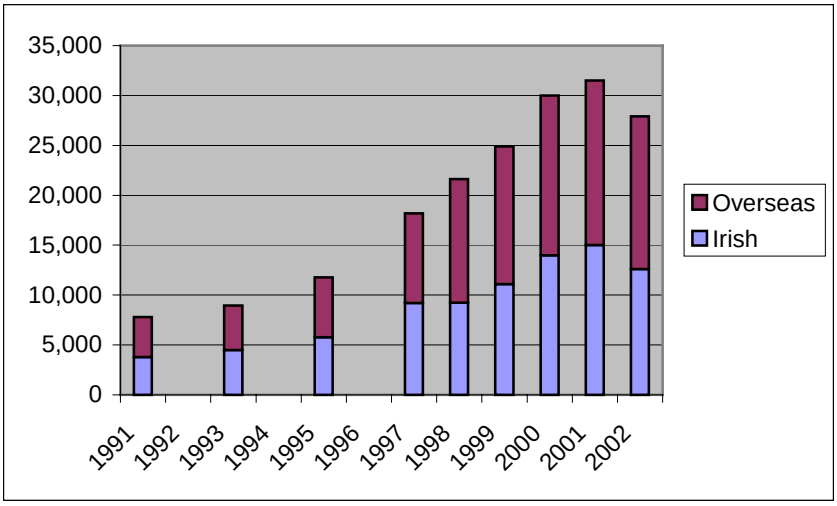
ICT is important for Ireland: the sector accounts for more than 10% of GDP. Foreign multinationals (Microsoft, IBM, HP, Oracle) dominate the cluster. They mostly have distribution, marketing and sales functions stationed in Dublin. Their R&D and production are done predominantly in the US. The indigenous ICT firms tend to have their entire supply chain present in Ireland.

The multinational software firms in Ireland employ over 11,000 people and account for 90% of the sector's product (2001). The indigenous software firms employ some 13,000 people, but only account for 10% of the sector's product. Figure 1 shows the Irish software industry employment. About 60% of all Irish ICT firms are established in Dublin. Indigenous firms include some big companies like Iona Technologies and Smartforce.

There are two primary locations for ICT firms in metropolitan Dublin: the south city centre and the city fringes near the M50 ring road. The former is favoured by indigenous firms, while the latter locations attract most of the multinationals. There are few exceptions to this location pattern. The multinationals settle in business parks, where they have access to large, relatively inexpensive, purpose-built office space. These companies seek a frictionless entrance into the local economy, and the business parks offer a good environment for building large operations quickly. Indigenous firms, being small to start, are more suited to the type of offices available in the city centre.

The city's universities (Trinity college, University College Dublin, Dublin City University) and its polytechnics are a key element in the cluster, and "produce" knowledge and skilled employees that are absorbed by the local companies.

Figure 1: Software Industry Employment in Ireland



Source: National Software Directorate, 2003

Network links

There is a big difference between the strategic networks of the multinationals and that of the indigenous firms. The multinationals tend to have few local linkages. Their interaction is predominantly with customers overseas and with other locations of the company in the US, Europe or Asia. The indigenous companies tend to work more in partnership with local firms and also have more relationships with local knowledge institutions.

Despite their low levels of interaction, multinationals have strongly contributed to the growth of the cluster. First, several managers started their own spin-off firms (some of which have become sizeable) and second, the presence of multinationals spurred the number of students in ICT-related subjects and contributed to the local knowledge base.

There are many close links between the cities' universities and ICT firms. Several firms have representatives on advisory boards of universities. Universities are also getting increasingly active in ICT incubator programs. University College Dublin has started NOVA, an innovation centre with 40 incubation units for high-tech campus companies, that involves investment and support from private companies, including banks, consulting firms, established ICT companies and Enterprise Ireland (the Irish agency that focuses on building an indigenous industry). Dublin City University recently opened a research and innovation

centre aimed at developing commercial applications in areas such as semiconductors and networking. The centre includes three national research institutes and also tries to involve private companies. The most successful university regarding commercialising of research has been Trinity College Dublin: it operates a high-grade innovation centre that cooperates with private firms in high-tech areas including ICT. The centre also includes incubator activities. The organisation was founded in the late 1980s with Industrial Development Agency Ireland support. Decreasing financial support from Irish government stimulated this commercialisation of research. Most of these cooperation links between firms and knowledge institutes are of fairly recent date.

Also, the Irish diaspora has had a key role in the establishment of global linkages of the cluster. While from the 1960s onwards, many Irish managers and other professionals emigrated in search of better job opportunities, this diaspora formed the basis for "contacts and then contracts" that set the software export market in motion. Reverse migration started to become very significant through the late 1990s, with returnees coming home to invest in software start-ups. Policymakers specifically and successfully targeted senior professionals with experience of sales, management and technology working abroad.

Institutional network setting

In Ireland, local and regional authorities have few means and competences. As a consequence, in the Dublin cluster, networks are supported and promoted predominantly by national institutions, either public or private. The private ISA (Irish Software Association) represents the majority of the Irish ICT cluster. It plays a key role in facilitating networking between actors in the cluster, but also heavily influences policymakers. Enterprise Ireland is a state agency, and provides a support structure –including funding, expertise, and international contacts- for start-ups and indigenous firms. Also, some universities are pro-active in creating local networks. Trinity College Dublin has been at the forefront in leading Ireland’s efforts to move research out of the universities and into the commercial sector. Its Innovation Centre is a prime initiative in this respect. But also the University College Dublin strongly supports business-university interactions, through its NOVA innovation centre.

4.4 Oulu

Oulu, Finland, is a provincial capital, located some 600 kilometres to the north of Helsinki. The relatively young population has increased sharply in the 1990s and now counts over 180,000 people. Public services and (high-tech) manufacturing are the biggest employers in the region, followed by financial intermediation and trade. In 1999 the total number of jobs in Oulu region was little over 75,000. The city has been remarkably successful in developing an

ICT cluster. ICT accounts for approximately 17% of total Oulu employment, which is an exceptionally high percentage.

Network nodes

In Oulu more than in any of the other cases, policy, both national and local, has shaped the cluster. The city did not have a large home market that would naturally support an ICT cluster, nor was it located near other markets. This explains its strength in sectors (R&D) in which market nearness is less important. National regional development policies, the set-up of a technical university, strong and consistent local policies and a co-operative culture fostered the cities' cluster. Instead of supporting declining industries, the Oulu region in the 1970s decided to enhance the co-operation between university and industry and rest on its own competence. The establishment of the university of Oulu, the laboratories of Technical Research Centre of Finland and the foundation of the first Science Park in Nordic Countries have been crucial factors to make growth of knowledge-based industries possible in the area. Nokia, as a locomotive company, has had very important impacts on the economic development of the region. In 1972 it started the production of U. S. military radio equipment by a license for the Finnish military forces. Regional policy has strongly influenced Nokia's location decision for Oulu: In the underdeveloped Northern areas, as all of the investment costs of buildings could be deducted in the year of building. In the end of 1973 the production of radio equipment, networks and radio links started and in 1975 Nokia Plc transferred a part of its production of modems and other equipment to Oulu. In 1981 the production of digital centres started with 100 employees. The actual R&D of mobile phones was launched in 1988 (Hyry et. al 2001, Männistö & Tervo, 1999). Nowadays Nokia Plc with its two divisions, Nokia Networks and Nokia Mobile Phones, is one of the biggest private employers in the Oulu region employing 4,300 people. The establishment of Nokia in the region generated a wave of establishment of new smaller firms in electronics and later in software industry (Männistö & Tervo 1999; 2000, Alatossava 1997).

In the 1990s, Oulu's fame as a technology centre began to rise, and the city began to appear frequently in the media. Oulu's fame as R&D competence centre also attracted foreign companies. In 2000, Ericsson opened a large research unit in Oulu. The unit is concentrating on research and development of data security on the mobile Internet. The city grew rapidly during the 1990s, and managed to attract professionals mainly from the northern part of Finland.

The ICT-sector is dominated by hardware; in 2000 64% of all ICT employees worked in hardware, followed by 10% in software. In the 1990s the educational level of the workforce

sharply increased. The firms in ICT are small: the majority employs less than 10 people. Software firms are the smallest; hardware companies are on average the biggest firms. Most start-ups are found in software and content.

Besides companies, knowledge institutes are important network nodes in Oulu. Infotech is a research centre inside the university of Oulu. Founded in 1996, its purpose is to stimulate long-term research and training in ICT in close interaction with other research organisations and private firms. Infotech also promotes transferring ICT research into practical solutions. In 2001 Infotech employed almost 500 people and external funding amounted to € 17.7m.

Another important knowledge institution is the Technical Research Centre of Finland: VTT. This is a non-profit research organisation owned by the national government; it has divisions throughout Finland. The VTT laboratories were created in 1974 as a result of national government's decentralisation policy and as a part of regional policy. VTT focuses on developing new mobile technologies, other telecom systems and software. In the beginning, VVT employed many engineers graduated at Oulu University; this helped to decrease the migration of graduates to southern Finland. VTT now employs 300 people and has about €30m in turnover (in 2001).

Network links

The strategic relationships in Oulu's ICT cluster involve local, regional, national and international linkages. Nokia is a spider in the global-local web. Large parts of its R&D are situated in Oulu, but its key relations are with the Helsinki headquarters and with other Nokia labs around the globe. At the same time, the company has intense relations with local suppliers and local university faculties, and actively participates in starters support and all kinds of regional initiatives.

The smaller companies in Oulu are also very networked; they work closely together with one another in joint projects, and tend to have good links to the local knowledge infrastructure. Cooperation between research & education institutes (Oulu Polytechnic and University) and companies is good and increasing, one reason being that public funding is increasingly allocated to programs where universities/polytechnics work together with firms. The close links between business and education are reflected in the participation of larger firms in educational committees and their financing of chairs.

Institutional network setting

Oulu is a relatively small place. This contributes to the fact that people from the ICT sector tend to know each other well. Informal relationships between key leaders in the cluster are

very common. At the science park, the physical concentration of companies and research institutes greatly facilitates interaction. But also, the region has a dense web of institutions that support interaction in the cluster. Tekes, the National Technology Agency, provides financial incentives for co-operation. It is the main financier for (R&D) projects of research organisations, firms, universities and polytechnics in Finland. Most Tekes projects demand a minimum funding involvement of two private companies that finance minimally 20% of the costs. Tekes provides expert services, loans and grants for R&D. Also, the organisation coordinates and finances participation in international technological activities like EU research programmes. Another organisation that stimulates strategic networking is the Institute for Management and Technological Training (POHTO Foundation). Established in 1972, the foundation offers courses, seminars and firm-specific programmes. Two big POHTO development programmes in Oulu aim to increase know-how in mechanics (international electronics industry standards) and production of electronics.

Public policies to stimulate ICT cluster development have been very important in Oulu: such policies were undertaken at the local, regional, national and European level. The municipality participated in Technopolis, and subsequently came up with a new industrial policy in 1984: “The City of Technology”. This helped create much positive publicity and established a positive image of Oulu as high-tech city. In the early 1990s, the regional strategy was revised to steer the high ICT growth that started in Oulu city in good directions in the total region. The year 1994 saw the launch of the Oulu Regional Centre of Expertise programme: the initiative – led by Technopolis – tries to unify local, regional and national resources to develop international competence areas. The programme works closely together with knowledge institutions and private firms. An important part of the programme is Mobile Forum Oulu, which comprises research, application and enterprise projects in mobile ICT applications. Besides Oulu, there are several other centres of expertise throughout Finland, all with their specific specialisation.

5. CONCLUSIONS

In this paper, with the use of a frame of analysis, we have presented four ICT clusters in different cities, situated in different countries. The main purpose was to describe and analyse local and non-local strategic linkages in the ICT clusters, and to assess the local institutional arrangements that support or promote these networks. In this section we compare the cases, and confront our findings with insights from the existing literature. Also, we draw some policy lessons.

Within ICT clusters, the composition of the cluster heavily influences the intensity and character of local strategic networks. In R&D-oriented (sub) clusters (Oulu, some parts of the Amsterdam and Dublin clusters), we found strong strategic linkages between companies and the knowledge infrastructure. The actors use each other's strengths (basic research versus the ability to produce, commercialise and market). Although technological innovation thrives on codified knowledge, which can be easily transmitted around the world using ICT infrastructures, the importance of proximity can be explained by the fact that R&D needs soft networks of social interaction (see Asheim and Cooke, 1999). Alderman's (1999) finding for the engineering industry that local networks do not matter in technical development processes is rebutted for our ICT cluster cases: proximity does matter in technical development. In the small-firm content industry (Amsterdam is a good example), networks are of a different nature. They are highly volatile; companies cooperate on short-term basis in projects. These networks serve to create scale, or produce new combinations (advertising agencies and software firms).

In all our case studies except Oulu, multinational companies have relatively few local strategic linkages. Multinationals try to exploit locational advantages by spatially splitting up their activities. Their internal corporate links –which are often global– are more important than local partnerships. IBM sits in Bari mainly for cost reasons, and is hardly embedded in the region; its prime partners are in the industrial powerhouses in northern Italy (Milan, Turin). Amsterdam's CISCO headquarters is oriented to the European mainland and its US headquarters. It chose Amsterdam not primarily for its potential local business partners but for its accessibility. Dublin's software multinationals also have few local links. Conversely, in Oulu where a large R&D establishment of Nokia is present, the embeddedness is much higher. It cooperates with indigenous SMEs and local universities. In doing so, it brings into the region international business experience and technological expertise, and links Oulu into global networks.

The impact of the multinationals on the receiving economies not only hinges on its local strategic links. In Ireland, initially the US software multinationals settled there for cost reasons and executed routine and low value-added activities. During the 1990s, they have steadily become more knowledge intensive. Despite low levels of local strategic partnerships, the multinationals have generated many knowledge spillovers and spinout companies, and have contributed to reverse migration of the well-educated Irish Diaspora.

A key question in this paper concerned the shape of local institutional arrangements to support networking in the different cases, and the role of local governments therein. Many

institutions in our cases date from the 1990s, when the ICT sector grew exponentially. The institutionalisation of the ICT sector can be seen as a sign of maturity. We found some indications that traditional local institutions and platforms did not meet the needs of actors in the ICT clusters. In Amsterdam, for instance, the establishment of the ANMA (Amsterdam New Media Association) reflected the desire for more informal and at the same time more intense network activities, as well as the wish to express common interests.

Our cases show that on the one hand, the shape of the institutions in the "new" ICT sector reflects local and national institutional traditions, and on the other, they vary with the composition and specialisation of the cluster. In Bari, the private sector dominates the network scene and is the key driver of network promotion. Despite heavy efforts of local and provincial governments to take the lead, in fact it is the local industry association that promotes the networks most. In Dublin, where local government is weak and has few competences, national government agencies such as Enterprise Ireland and the Industrial Development Authority take the lead, together with the Irish Software Association. In Amsterdam, the municipality constructively supports local initiatives but plays it low key. In Oulu, in the Nordic tradition, the role of the public sector is greatest. National and local agencies invest substantial efforts and money into the promotion of networks, but they do so in close co-operation with the business sector. An interesting feature of the Oulu model (but it is applied in other Finnish regions as well) is that national policies and incentives are geared towards local needs. National, regional and local resources are unified and invested in international competence areas in which a region has specific strengths. In addition, TEKES (a national technology fund) successfully promotes networks by giving strong financial incentives for co-operation.

The composition and specialisation of the cluster influence the institutional networks setting. Our cases suggest that R&D and technological (sub-) clusters have a heavier institutional support structure than the other (sub-) clusters. This supports the notion that exchange of complex tacit knowledge (often with an uncertain value) requires more structured and organised co-operation.

Our case studies, perhaps with Oulu as an exception, suggest that local policy is only a tiny factor in ICT cluster development: Market developments and national policy are more important. Interestingly, in some of our cases (Bari, Dublin) we found that national policies to decrease funding for universities had a positive impact on the strategic links between universities and the local industry: In search of financial means, the universities had to become more market-oriented and started to cooperate with local companies.

This article points to the limitations and possibilities of local governments to influence ICT clusters. The case of Oulu suggests that policies are most likely to be successful when there is close collaboration with the private sector, with other (regional, national, European) government initiatives and incentives. The low-key municipal ICT policy in Amsterdam is suitable, since the cluster is doing well without much outside help. Additionally we may conclude that cluster policy should be based on a thorough knowledge of the composition and specialisation of the cluster, the existing linkages, and the spatial dynamics in the ICT sector.

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